Analysis of hydrological dynamics and hydropower generation in a West African anthropized watershed in a context of climate change

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BACKGROUNDS

Hydropower dams are considered as real assets of socio-economic development (Korkovelos *et al*. 2018). However, the artificial water reservoirs formed by these dams are influenced by hydrological variations, making difficult their rational exploitation. Previous studies conducted by Amoussou (2010; 2012) in the Mono-Ahémé-Couffo watershed have shown that the availability of water resources is related to the spatio-temporal variability of rainfall and to the flows varying at monthly, seasonal and annual time scales.

In this context, it is important to understand how hydrological variability modulates the flows in the basin and its potential impacts on hydropower generation under climate change. This paper aims to analyze the hydrological functioning of Bandama watershed and to assess hydrological dynamics at the entrance and the exit of the hydropower dam Kossou.

DATA AND METHODOLOGY

Data

- Daily weather data of 33 stations (1980-2013)
- Monthly precipitation data from three climate models of CMIP5 and three climate models of CORDEX-AFRICA (1980-2050)
- Observed hydrometric data of 2 stations: Tortiya-aval (1980-1996) and Kossou (1980-2013)
- Monthly data of hydropower generation of Kossou hydropower plant (1980-2017)

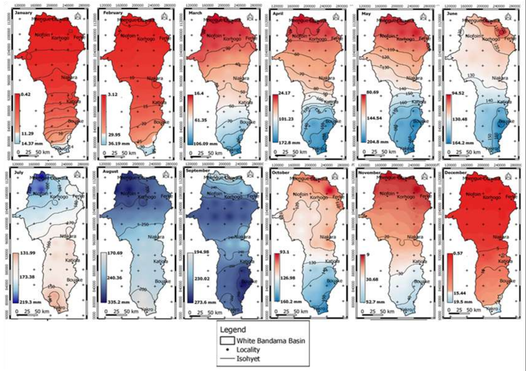
Methods

- **Characterization of the spatio-temporal variability of rainfall in the watershed** Inverse Distance Weighted (IDW) interpolation method (Bartier and Keller 1996; Achilleos 2011)
- **Detection of breaks and climatic variability** Normality, Buishand, Pettitt and Hubert tests (IRD-ORSTOM 1998; Paturel *et al*. 1996; Servat *et al*. 1997, 1998; Traore *et al*. 2017);
  Method of standardized anomalies on rainfall and streamflow (Goula *et al*. 2006)
- **Characterization of the streamflow variability** calculation of Flow Coeffcient (Mahé and Olivry 1995; Amoussou et al. 2012)
- **Analysis of the evolution of hydropower generation at Kossou in a context of climate change**

RESULTS AND DISCUSSION

Spatio-temporal variability of rainfall

The rainfall varies in the basin just as well monthly, seasonally than annually. The maximum monthly precipitations occur in August and September with respectively 335 and 273 mm. The driest months are December and January with less than 20 mm. The wet season corresponds from April to October and dry season from November to March.

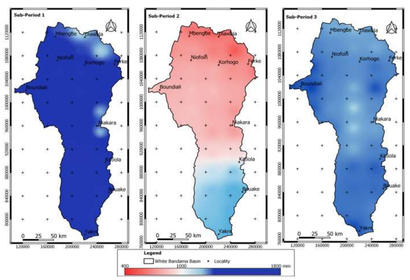


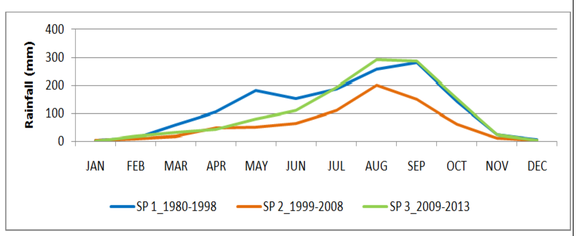
Breaks detection and climatic variability in the basin

The statistical tests detected breaks in stationarity with three sub-periods

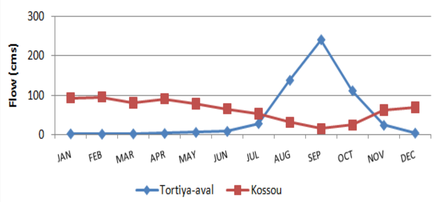
Basin	Period	Tests			Start	End	Sub-Periods	average	Standard deviation	Balance		
		Buishand	Pettitt	Hubert								
White Bandama	From 1980 to 2013	R	R	Scheffe's level of significance 1%	1980	1998	SP1	1427.02	210.530	Humid period	From SP1 to SP2 Deficit (-48.8%)	From SP1 to SP3 Deficit (-13.1%)
					1999	2008	SP2	730.40	219.235	Dry period	From SP2 to SP3 Surplus (+69.9%)	
					2009	2013	SP3	1240.18	126.135	Humid period		

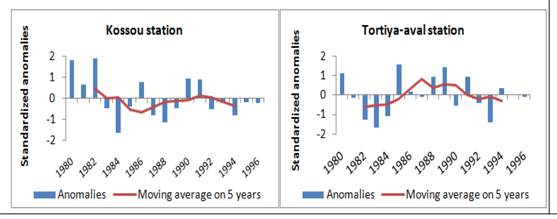
SP1: bimodal regime with maximum precipitation in May and September. SP2 and the SP3: unimodal regime with maximum precipitation in August



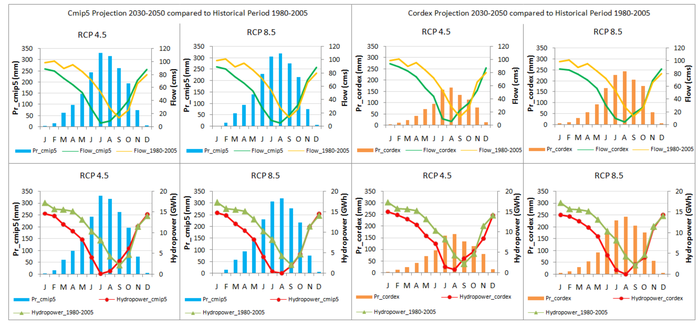


Streamflow variability





Evolution of hydropower generation at Kossou in a context of climate change



CONCLUSION AND PERSPECTIVES

This study showed that there is a spatio-temporal variability of rainfall in the basin from 1980 to 2013. This variability is as well interannual, seasonal as monthly. The dry season is from November to March and the wet season is from April to October. There are breaks in series with three sub-periods. There is also a variability of flow in Tortiya and Kossou. The dam Kossou plays a role in reducing floods. The variability in rainfall and flow will affect hydropower generation at Kossou dam from 2030 to 2050 under RCP 4.5 and 8.5. An improvement of this work could be made by including the effect of landuse/landcover.

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Conflict of Interest: The authors declare that they have no conflict of interest